

Design and Implementation of a high performance IPC for Intrusion Prevention using Socket API

Bachelorthesis

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Agenda

- 1 Motivation
- 2 Design
- 3 Implementation
- 4 Experiments



Motivation

Motivation



Host-based intrusion detection and prevention

Threats:

- access data,
- manipulate data, or
- render a system unreliable or unusable.



Host-based intrusion detection and prevention

Necessity for Intrusion Prevention Systems:

- 1 The majority of systems have vulnerabilities, rendering them susceptible.
- 2 Replacing systems with known vulnerabilities is difficult. Specific features may only be present in the less-secure system.
- 3 Developing absolutely secure systems is difficult, since the explicit absence of vulnerabilities can rarely be proven.
- 4 Secure systems remain vulnerable to insiders misusing their privileges.



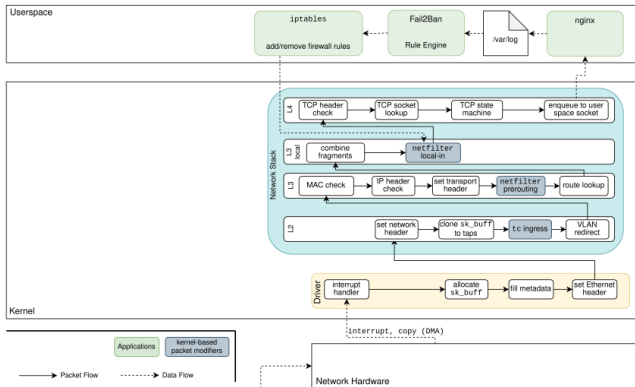
Motivation - Fail2ban

Fail2ban application creates "jails":

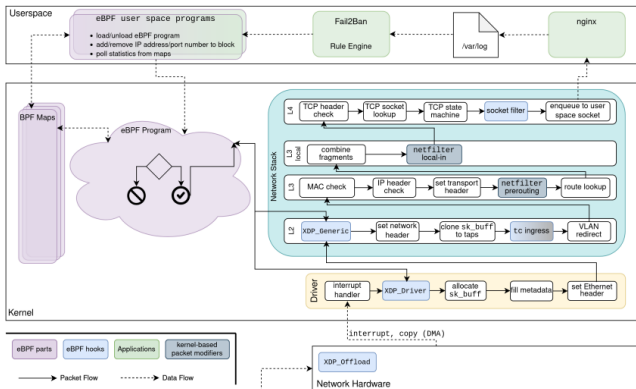
- 1 A jail consists out of:
 - Log path
 - Specific filter (uses Regex)
 - A defined action
 - Multiple customizable parameters (Ban duration, Ban limit)
- 2 Jails are saved on persistent storage
- 3 Deduces vital client information from log messages



Motivation - Fail2ban

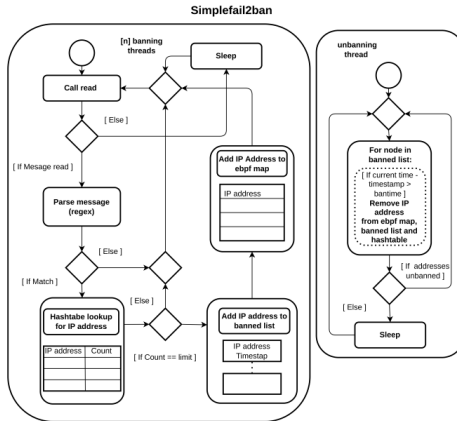


Motivation - Fail2ban



Florian Mikolajczak: Implementation and Evaluation
of an Intrusion Prevention System Leveraging eBPF on the Basis of Fail2Ban

Motivation - Fail2ban



Design

Design



UNIX domain sockets

An alternative to the shared memory mode: UNIX domain Sockets

- 1 Preferred over internet sockets
- 2 Three types of UNIX domain sockets:
 - SOCK_STREAM: Stream-oriented socket. Establishes connections and keeps them open until explicitly closed.
 - SOCK_DGRAM: Datagram-oriented socket. Preserves message boundaries. Mostly reliable.
 - SOCK_SEQPACKET: Sequence-packet socket. Is connection-oriented, preserves message boundaries, and retains the order in which data was sent.



UNIX domain sockets

An alternative to the shared memory mode: UNIX domain Sockets

1 Preferred over internet sockets

2 Three types of UNIX domain sockets:

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-> `SOCK_SEQPACKET` is preferred



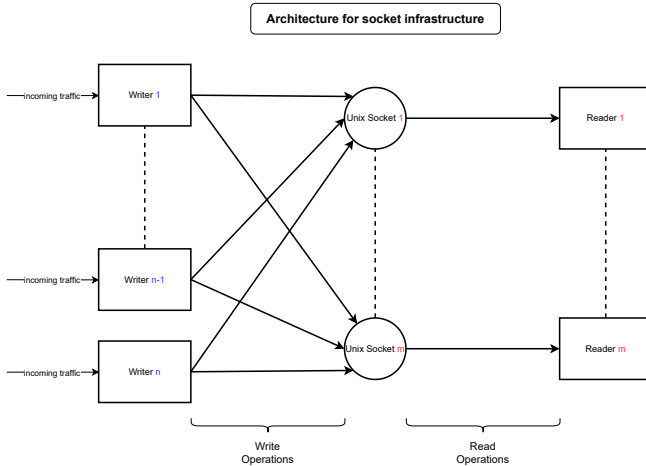
UNIX domain sockets

An alternative to the shared memory mode:

- 1 Existing support on all UNIX systems
- 2 Established Write and Read API
- 3 Kernel-based IPC promising low latency and high bandwidth
- 4 Easily scalable beyond the local system



UNIX domain sockets



Implementation

Implementation



Shared parameters

Shared parameters:

```
1 #define MAX_AMOUNT_OF_SOCKETS 32
2 #define SOCKET_TEMPLATE_LENGTH 128
3 #define SOCKET_NAME_TEMPLATE
    "/tmp/unixDomainSock4SF2B_"
```

Union defining which process is calling a function:

```
1 union sock_arg_t{
2     struct sock_writer_arg_t wargs;
3     struct sock_reader_arg_t rargs;
4 };
```



Auxiliary functions

Initialization of socket IPC:

```
1 int sock_init(  
2     union sock_arg_t *sock_args ,  
3     int role  
4 );
```

Cleanup of socket IPC:

```
1 int sock_cleanup(  
2     union sock_arg_t *sock_args ,  
3     int role  
4 );
```



Write API

Writer structure:

```
1 struct sock_writer_arg_t
2 {
3     char socketPathNames
4         [MAX_AMOUNT_OF_SOCKETS][SOCKET_TEMPLATE_LENGTH];
5     struct sockaddr_un
6         socketConnections[MAX_AMOUNT_OF_SOCKETS];
7     int socketRecvS[MAX_AMOUNT_OF_SOCKETS];
8     int writeSockets[MAX_AMOUNT_OF_SOCKETS];
9 };

```



Write API

Write function:

```
1 int sock_writev(  
2     struct sock_writer_arg_t *sock_args ,  
3     struct iovec *log_iovs ,  
4     uint16_t invalid_count ,  
5     uint16_t maxNumOfSocks  
6 );
```



Read API

Reader structure:

```
1 struct sock_reader_arg_t
2 {
3     char socketPathName[SOCKET_TEMPLATE_LENGTH];
4     struct sockaddr_un address;
5     int sizeOfAddressStruct;
6     int readSocket;
7     int clientSockets[MAX_AMOUNT_OF_SOCKETS];
8 };
```



Read API

Read function:

```
1 int sock_readv(  
2     struct sock_reader_arg_t *sock_args ,  
3     struct iovec *iovecs  
4 );
```

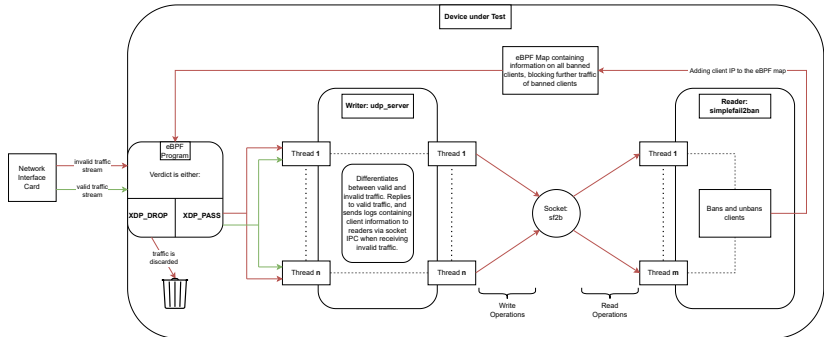


Experiments

Experiments



Device under Test

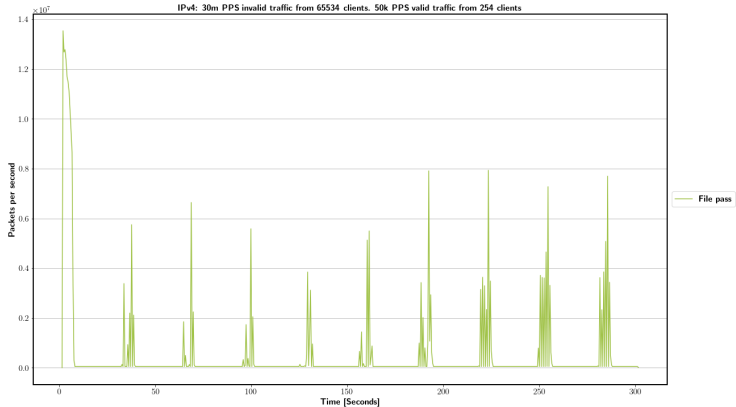


Factors and their levels

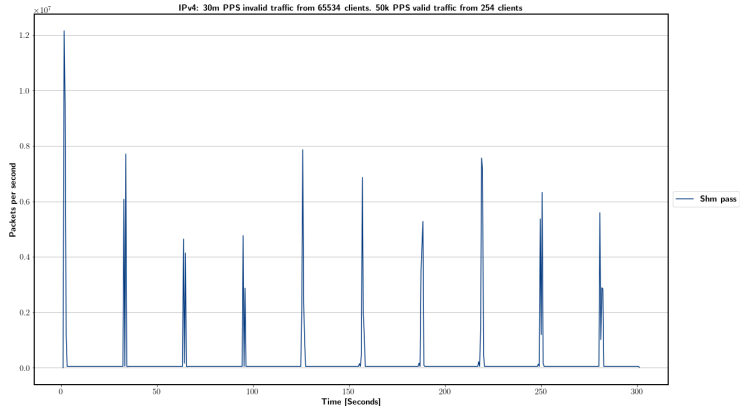
- 1 IP stack: IPv4, IPv6 and IPv4/IPv6 mixed
- 2 Effects of differing amount of invalid traffic sent: 100k, 1M, 10M, 20M, 30M PPS
- 3 Effects of differing number of clients sending invalid data: 65,534 (from 256 subnets) and 131,068 (from 512 subnets)
- 4 Differing IPC type: FILE (traditional file-based logging), SHM (using shared memory), SOCK (using UNIX domain sockets)
 - If applicable: No 2nd Reader/ Enabling 2nd Reader



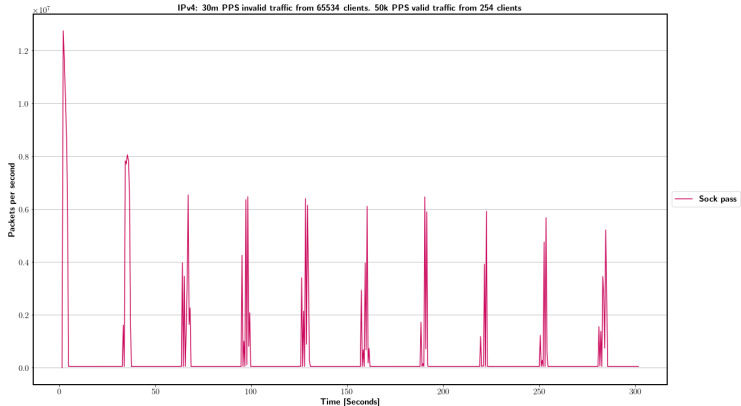
File pass: IPv4 - 65534 Clients - 30M invalid PPS



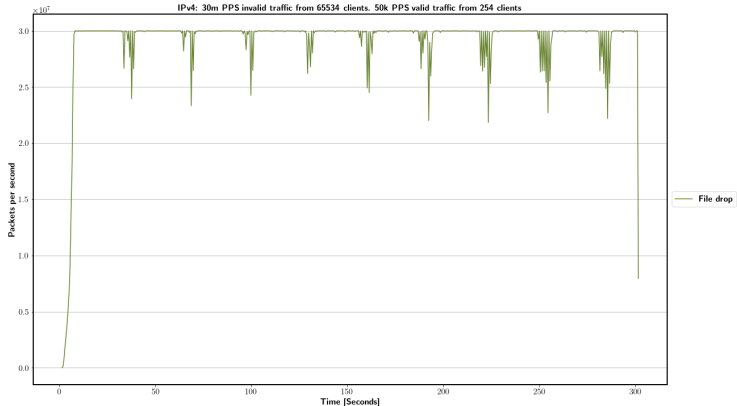
Shm pass: IPv4 - 65534 Clients - 30M invalid PPS



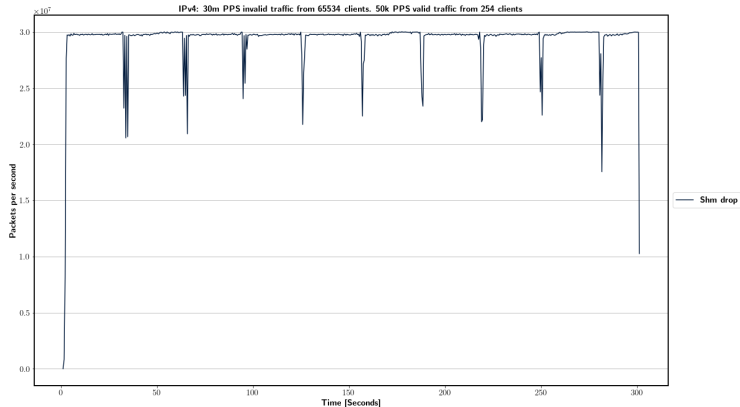
Sock pass: IPv4 - 65534 Clients - 30M invalid PPS



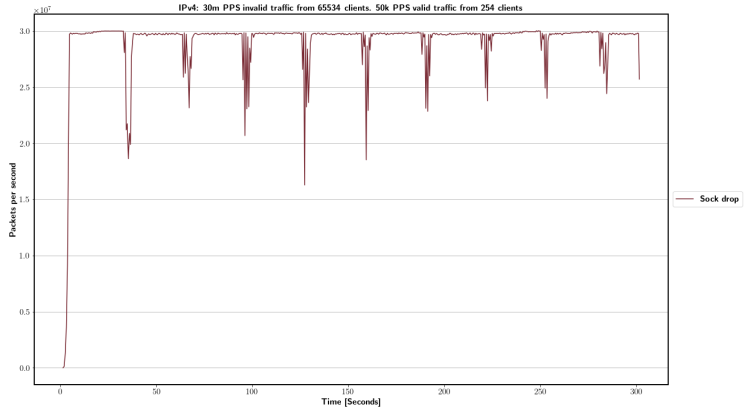
File drop: IPv4 - 65534 Clients - 30M invalid PPS



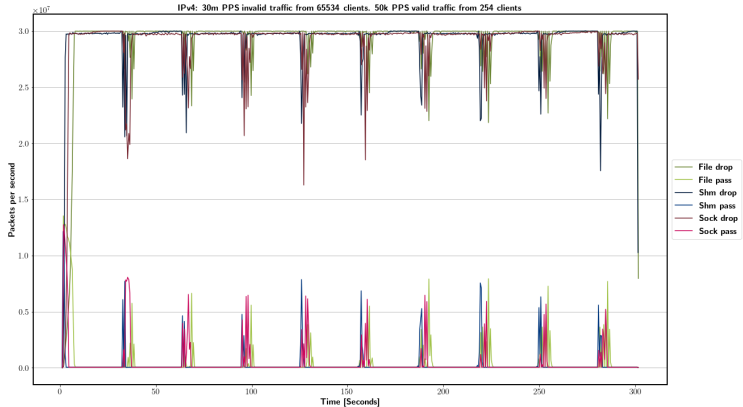
Shm drop: IPv4 - 65534 Clients - 30M invalid PPS



Sock drop: IPv4 - 65534 Clients - 30M invalid PPS



IPv4 - 65534 Clients - 30M invalid PPS - 50k valid PPS



IPv4 - 65534 Clients - 30M invalid PPS - 50k valid PPS

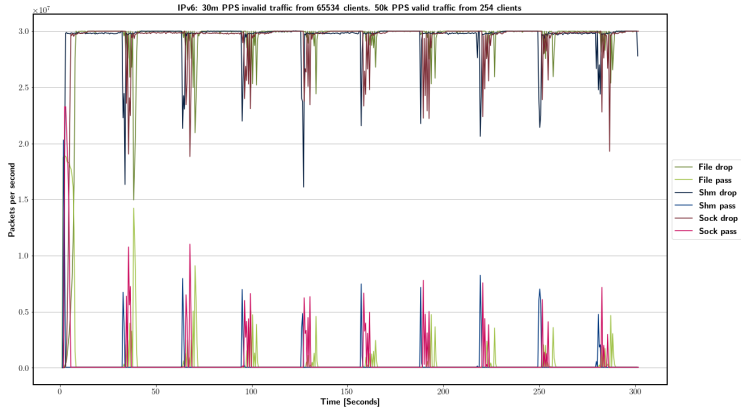
IPC type	XDP_DROP [10^8]	XDP_PASS [10^6]	Relative drop [%]
File	87.75	159.82	97.52375345
Shm	88.30	87.23	98.13105047
Sock	87.45	139.42	97.18179422

IPC type	Packets received by udp_server [10^6]	Log messages [10^6]	CPU [seconds]
File	17.48	4.07	16.55
Shm	21.39	6.99	39.08
Sock	16.92	3.16	138.85

Total packets sent: 9,015m. Best-case drop rate: 99.97815533%



IPv6 - 65534 Clients - 30M invalid PPS - 50k valid PPS



IPv6 - 65534 Clients - 30M invalid PPS - 50k valid PPS

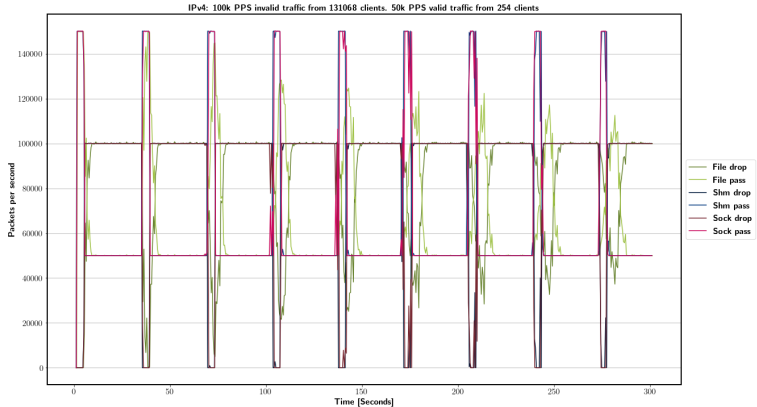
IPC type	XDP_DROP [10^8]	XDP_PASS [10^6]	Relative drop [%]
File	87.41	211.05	97.14091697
Shm	88.63	85.55	98.50239609
Sock	87.77	170.03	97.54838057

IPC type	Packets received by udp_server [10^6]	Log messages [10^6]	CPU [seconds]
File	17.20	3.87	22.51
Shm	21.79	7.24	46.03
Sock	16.92	3.00	149.69

Total packets sent: 9,015m. Best-case drop rate: 99.97815533%



IPv4 - 131068 Clients - 100k invalid PPS - 50k valid PPS



IPv4 - 131068 Clients - 100k invalid PPS - 50k valid PPS

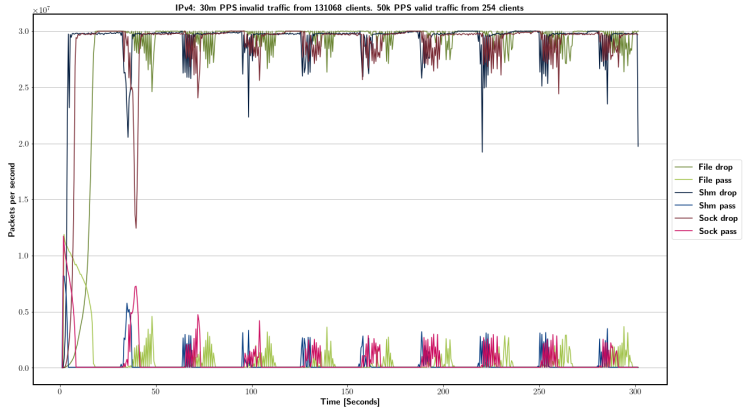
IPC type	XDP_DROP [10^6]	XDP_PASS [10^6]	Relative drop [%]
File	25.99	19.01	99.69409958
Shm	26.46	18.54	101.5083842
Sock	26.44	18.56	101.4395334

IPC type	Packets received by udp_server [10^6]	Log messages [10^6]	CPU [seconds]
File	18.16	3.54	08.34
Shm	18.54	3.54	10.14
Sock	18.53	3.54	100.40

Total packets sent: 45m. Best-case drop rate: 86.8932%



IPv4 - 131068 Clients - 30M invalid PPS - 50k valid PPS



IPv4 - 131068 Clients - 30M invalid PPS - 50k valid PPS

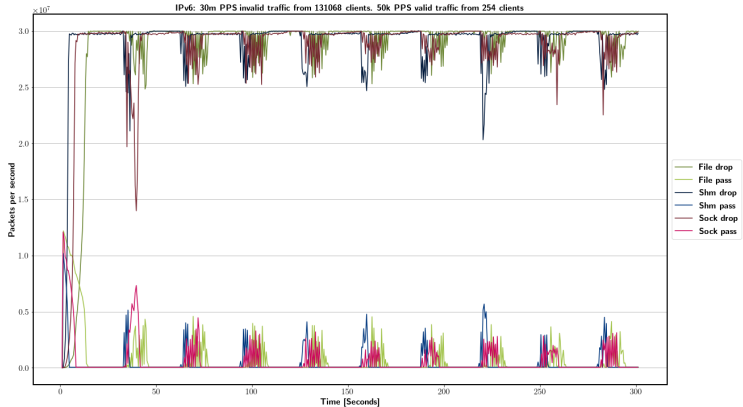
IPC type	XDP_DROP [10^8]	XDP_PASS [10^6]	Relative drop [%]
File	85.02	238.30	94.51036756
Shm	87.57	104.14	97.33826458
Sock	86.12	180.89	95.73084169

IPC type	Packets received by udp_server [10^6]	Log messages [10^6]	CPU [seconds]
File	18.04	7.44	38.99
Shm	25.32	11.50	71.92
Sock	18.33	5.93	323.02

Total packets sent: 9,015m. Best-case drop rate: 99.95631067%



IPv6 - 131068 Clients - 30M invalid PPS - 50k valid PPS



IPv6 - 131068 Clients - 30M invalid PPS - 50k valid PPS

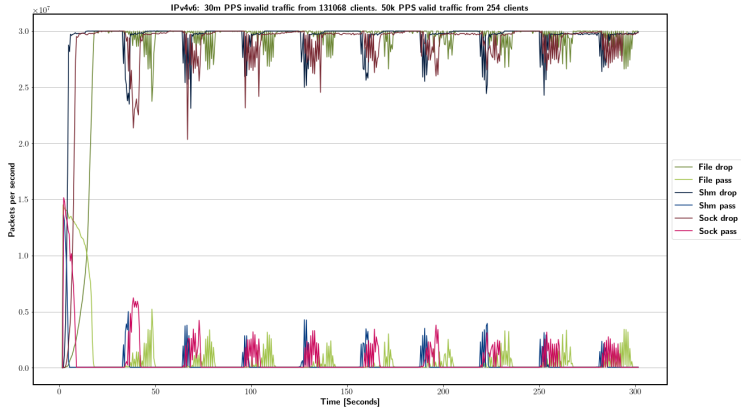
IPC type	XDP_DROP [10^8]	XDP_PASS [10^6]	Relative drop [%]
File	85.73	228.07	95.29278185
Shm	87.60	109.08	97.37706621
Sock	86.21	177.33	95.82614459

IPC type	Packets received by udp_server [10^6]	Log messages [10^6]	CPU [seconds]
File	17.90	6.91	38.41
Shm	25.08	11.15	74.71
Sock	18.67	6.18	317.37

Total packets sent: 9,015m. Best-case drop rate: 99.95631067%



IPv4v6 - 131068 Clients - 30M invalid PPS - 50k valid PPS



IPv4v6 - 131068 Clients - 30M invalid PPS - 50k valid PPS

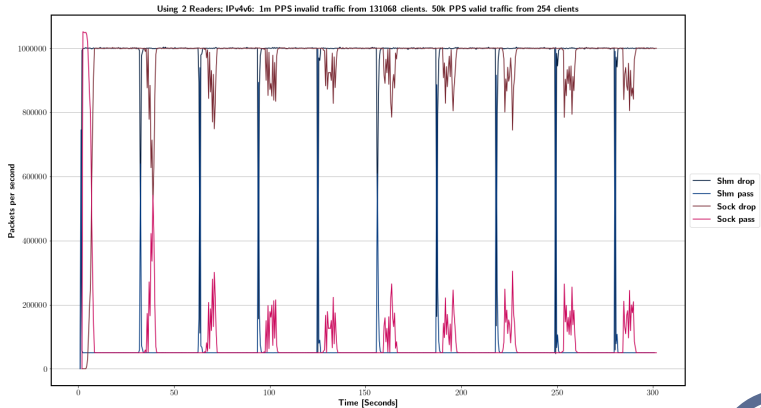
IPC type	XDP_DROP [10^8]	XDP_PASS [10^6]	Relative drop [%]
File	85.12	286.15	94.61335186
Shm	88.02	105.83	97.84149307
Sock	86.30	212.81	95.93428297

IPC type	Packets received by udp_server [10^6]	Log messages [10^6]	CPU [seconds]
File	17.69	7.07	47.15
Shm	25.13	11.16	94.64
Sock	18.00	5.99	353.34

Total packets sent: 9,015m. Best-case drop rate: 99.95631067%



IPv4v6 2nd Reader - 131068 Clients - 1M invalid PPS - 50k valid PPS



IPv4v6 2nd Reader - 131068 Clients - 1M invalid PPS - 50k valid PPS

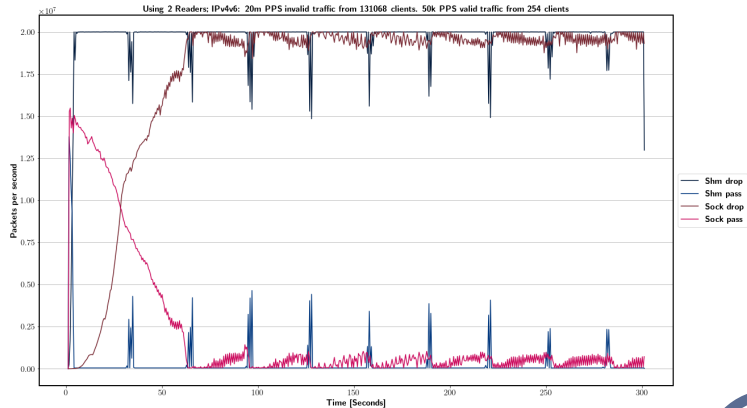
IPC type	XDP_DROP [10^7]	XDP_PASS [10^6]	Relative drop [%]
Shm	29.53	19.75	99.72283593
Sock	28.91	25.94	97.6334018

IPC type	Packets received by udp_server [10^6]	Log messages [10^6]	CPU [seconds]
Shm	19.48	4.49	17.76
Sock	18.29	4.15	80.82

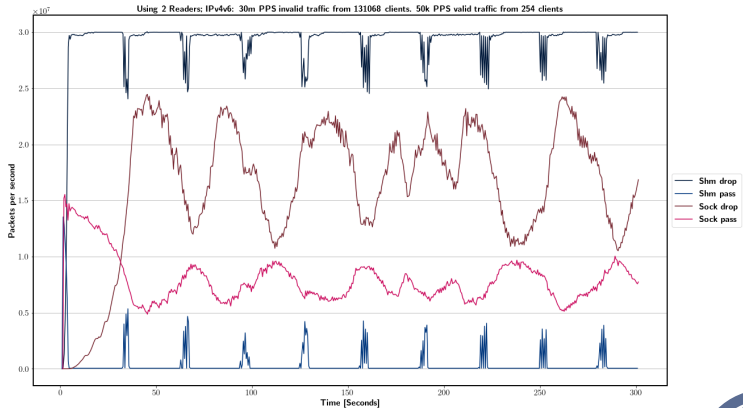
Total packets sent: 9,015m. Best-case drop rate: 99.95631067%



IPv4v6 2nd Reader - 131068 Clients - 20M invalid PPS - 50k valid PPS



IPv4v6 2nd Reader - 131068 Clients - 30M invalid PPS - 50k valid PPS



Questions?

Questions?

